

ROUND 13A

TOSS-UP

1) Chemistry – *Short Answer* Order the following three solvents from least to greatest by the pKa of acetic acid when dissolved in that solvent: 1) DMSO; 2) Water; 3) Methanol.

ANSWER: 2, 3, 1

BONUS

1) Chemistry – *Short Answer* Order the following three colors of light from least energetic to most energetic: 1) Yellow; 2) Violet; 3) Red.

ANSWER: 3, 1, 2

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### TOSS-UP

2) Energy – *Short Answer* Identify all of the following three statements that illustrate disadvantages of hydroelectricity plants: 1) Water used to run the plant may be reliant on precipitation; 2) The plants can produce a lot of pollution; 3) Aquatic habitats near the plants may be destroyed.

ANSWER: 1 AND 3

### BONUS

2) Energy – *Multiple Choice* Which of the following establishes renewable energy use goals for the U.S. by a specific date?

- W) Net Metering Agreement
- X) National Renewable Energy Target Contract
- Y) Solar Guerrillas Pact
- Z) Renewable Energy Portfolio Standards

ANSWER: Z) RENEWABLE ENERGY PORTFOLIO STANDARDS

**TOSS-UP**

3) Math – *Short Answer* What is the sum of the largest prime number less than 50 and the largest prime number less than 100?

ANSWER: 144

**BONUS**

3) Math – *Short Answer* The bob on a pendulum swings through an arc 6 feet long when the string swings through an angle of 0.5 radians. What is the length of the pendulum in feet?

ANSWER: 12



**TOSS-UP**

4) Earth and Space – *Multiple Choice* Which of the following is always true during the month of July?

- W) The Earth is near its orbital perihelion
- X) The Southern Hemisphere is tilted towards the Sun
- Y) The sun does not rise over the Drake Passage
- Z) The sun does not set over Svalbard

ANSWER: Z) THE SUN DOES NOT SET OVER SVALBARD

**BONUS**

4) Earth and Space – *Short Answer* What is the resolving power, in arc seconds to one decimal place, of a 56.0 centimeter diffraction-limited telescope observing in the V band?

ANSWER: 0.2

### TOSS-UP

5) Physics – *Short Answer* What fundamental force mediates the decay of a neutron into a proton, an electron, and a neutrino?

ANSWER: WEAK FORCE (ACCEPT: WEAK NUCLEAR FORCE; WEAK NUCLEAR; WEAK)

### BONUS

5) Physics – *Multiple Choice* Through which of the following materials does sound travel the fastest?

- W) Aluminum
- X) Copper
- Y) Glass
- Z) Gold

ANSWER: W) ALUMINUM

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TOSS-UP

6) Biology – *Short Answer* What group of biotech-relevant enzymes, derived from bacteria, often recognize specific palindromic sequences of nucleic acids and introduce a double-stranded break?

ANSWER: RESTRICTION ENZYMES (ACCEPT: RESTRICTION ENDONUCLEASES)

BONUS

6) Biology – *Multiple Choice* An effective enzyme has a very high affinity for which of the following?

- W) Starting materials
- X) Products
- Y) Transition state
- Z) ATP

ANSWER: Y) TRANSITION STATE

TOSS-UP

7) Chemistry – *Short Answer* Identify all of the following three intermolecular forces that will arise between molecules of methanol: 1) London forces; 2) Dipole-dipole interactions; 3) Hydrogen bonding.

ANSWER: ALL OF THEM

BONUS

7) Chemistry – *Short Answer* Identify all of the following three statements that are true regarding carbon and graphite: 1) Carbon atoms in diamond are sp^3 hybridized; 2) Graphite is a better conductor of electricity than diamond; 3) Graphite carbon is tetrahedral.

ANSWER: 1 AND 2

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### TOSS-UP

8) Earth and Space – *Multiple Choice* Which of the following sedimentary rocks has a clastic composition?

- W) Dolostone
- X) Limestone
- Y) Shale
- Z) Coal

ANSWER: Y) SHALE

### BONUS

8) Earth and Space – *Short Answer* Identify all of the following three statements that are TRUE regarding calderas: 1) Calderas can form atop shield volcanoes; 2) Basalt-filled calderas tend to result from explosive eruptions; 3) Calderas can be found on Venus and Io.

ANSWER: 1 AND 3

### TOSS-UP

9) Physics – *Short Answer* What thermodynamic cycle, most often found in jet engines, uses adiabatic compression and expansion processes as well as isobaric heating and cooling processes?

ANSWER: BRAYTON CYCLE

### BONUS

9) Physics – *Multiple Choice* A former Russian service officer died in November 2006 after being diagnosed with acute radiation syndrome. During the investigation into his death, authorities were able to trace his activities, in part, because his body had excreted trace amounts of which of the following radioactive isotopes, which he had recently ingested?

- W) Polonium-210 with a half-life of 138 days
- X) Bismuth-213 with a half-life of 45 minutes
- Y) Technetium-99 with a half-life of 6 hours
- Z) Uranium-238 with half-life of 4.5 billion years

ANSWER: W) POLONIUM-210 WITH A HALF-LIFE OF 138 DAYS

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TOSS-UP

10) Energy – *Short Answer* What environmental secondary pollutant results from sulfur dioxide that is produced during the combustion of fossil fuels?

ANSWER: ACID PRECIPITATION (ACCEPT: ACID RAIN, SULFURIC ACID, H₂SO₄)

BONUS

10) Energy – *Short Answer* During operation of a nuclear power plant, some non-fuel uranium-238 present in the fuel is converted to a different element, which then acts as fuel to provide about 1/3 of the total energy. What is this second element?

ANSWER: PLUTONIUM

TOSS-UP

11) Math – *Multiple Choice* In the conversion of the rectangular coordinates (-8, 6) into polar coordinates, to the nearest whole number, what is the degree measure of the angle?

- W) 127
- X) 143
- Y) 307
- Z) 323

ANSWER: X) 143

BONUS

11) Math – *Short Answer* What is the area, in square centimeters, of an equilateral triangle whose circumcircle has a radius of 10 centimeters?

ANSWER: $75\sqrt{3}$

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### TOSS-UP

12) Biology – *Short Answer* What enzyme, found in the human stomach, is activated by hydrochloric acid and breaks down proteins?

ANSWER: PEPSIN

### BONUS

12) Biology – *Short Answer* Identify all of the following three pathways during which oxidative phosphorylation [*faws-four-il-AY-shun*] occurs: 1) Photosynthesis; 2) Krebs cycle; 3) Electron transport chain.

ANSWER: 1 AND 3

### TOSS-UP

13) Energy – *Multiple Choice* According to the US Energy Information Administration, which of the following is closest to the percentage of worldwide electricity produced using renewable sources in 2011?

- W) 5
- X) 20
- Y) 30
- Z) 50

ANSWER: X) 20

### BONUS

13) Energy – *Multiple Choice* Which one of these factors is NOT used for determining what chemicals are blended to make gasoline?

- W) Season
- X) Ease of transportation
- Y) Local emission requirements
- Z) Cost of components

ANSWER: X) EASE OF TRANSPORTATION

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TOSS-UP

14) Biology – *Short Answer* In the presence of high amounts of citrate, the reaction catalyzed by the glycolytic enzyme phosphofructokinase [*faws-fo-frook-tow-KYE-nase*] slows down. Identify all of the following three types of enzyme inhibition that occur in this example: 1) Competitive; 2) Allosteric; 3) Feedback.

ANSWER: 2 AND 3

BONUS

14) Biology – *Multiple Choice* Which of the following is NOT considered to be a tumor suppressor protein?

- W) Rb
- X) PTEN
- Y) HER2/neu [*her-TWO - new*]
- Z) p53

ANSWER: Y) HER2/NEU

TOSS-UP

15) Chemistry – *Short Answer* Gloria transfers 10 milliliters of an ideal gas at 200,000 kilopascals to a 1 liter flask. In kilopascals, what is the final pressure of the gas?

ANSWER: 2000

BONUS

15) Chemistry – *Short Answer* Identify all of the following three statements that are TRUE concerning colligative properties: 1) Boiling point elevation is proportional to the molality of particles in a solution; 2) The Van't Hoff factor for calcium chloride is close to 2; 3) Adding a solid solute often increases the vapor pressure of a solution.

ANSWER: 1



TOSS-UP

16) Math – *Short Answer* What is the product of the complex numbers $3 + i$ and $2 + 3i$?

ANSWER: $3 + 11i$

BONUS

16) Math – *Short Answer* What is the remainder when $3x^3 + 6x^2 - 7x + 2$ is divided by the binomial $x + 4$?

ANSWER: -66

TOSS-UP

17) Physics – *Multiple Choice* What is the name of the postulate of quantum mechanics that requires that quantum mechanical systems behave classically as quantum numbers approach infinity?

- W) Correspondence principle
- X) Born approximation
- Y) Heisenberg postulate
- Z) Wigner-Eckart theorem

ANSWER: W) CORRESPONDENCE PRINCIPLE

BONUS

17) Physics – *Multiple Choice* The compressor in a Carnot engine performs which of the following types of compression?

- W) Isobaric
- X) Isotropic
- Y) Isentropic
- Z) Isochoric

ANSWER: Y) ISENTROPIC

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### TOSS-UP

18) Earth and Space – *Short Answer* What region of the H-R diagram, named after a Japanese astrophysicist, is occupied by protostars of fewer than 3 solar masses?

ANSWER: HAYASHI TRACK

### BONUS

18) Earth and Space – *Short Answer* A given mineral sample consists of pale yellow rhombohedral crystals that scratch gypsum. A laser beam directed through the sample splits in two, and a drop of hydrochloric acid placed on the sample effervesces vigorously. What is the chemical formula of the mineral?

ANSWER:  $\text{CaCO}_3$

**TOSS-UP**

19) Math – *Short Answer* A special coin has a  $1/3$  probability of landing on heads, and a  $2/3$  probability of landing on tails. In a series of three coin flips, what is the probability of the outcome sequence heads, heads, tails?

ANSWER:  $2/27$

**BONUS**

19) Math – *Short Answer* What is the average value of the function  $f(x) = x^2$  over the interval  $-2$  to  $2$ ?

ANSWER:  $4/3$



**TOSS-UP**

20) Earth and Space – *Multiple Choice* If the ambient air cools 8 degrees Celsius for each kilometer of vertical elevation you gain as you ascend a low mountain in Tennessee, which of the following most likely describes the stability of the local atmosphere?

- W) Absolutely unstable
- X) Conditionally unstable
- Y) Neutrally stable
- Z) Absolutely stable

ANSWER: X) CONDITIONALLY UNSTABLE

**BONUS**

20) Earth and Space – *Short Answer* Order the following four planets from least dense to most dense: 1) Mercury; 2) Mars; 3) Jupiter; 4) Saturn.

ANSWER: 4, 3, 2, 1 (ACCEPT: SATURN, JUPITER, MARS, MERCURY)

### TOSS-UP

21) Biology – *Short Answer* To prevent the body from metabolizing Drug G too quickly, a pharmaceutical company develops Substance Q to be taken concurrently with Drug G. If Substance Q binds to the enzyme catalyzing the metabolism of Drug G and alters its active site, what type of inhibition is occurring?

ANSWER: NON-COMPETITIVE INHIBITION

### BONUS

21) Biology – *Short Answer* Identify all of the following four plant structures that are determinate:

1) Leaves; 2) Shoot apical meristems; 3) Root apical meristems; 4) Flowers.

ANSWER: 1, 4 (ACCEPT: LEAVES, FLOWERS)

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TOSS-UP

22) Chemistry – *Short Answer* Consider a gaseous mixture of helium and molecular hydrogen that is allowed to equilibrate to a constant internal temperature. What is the ratio of the root-mean-square speed of hydrogen molecules to that of helium atoms?

ANSWER: SQUARE ROOT OF 2 (ACCEPT: $\sqrt{2}$ TO 1)

BONUS

22) Chemistry – *Short Answer* Identify all of the following three organic reactions in which carbon atoms are reduced: 1) Transformation of alkanes into alcohols; 2) Transformation of ketones into secondary alcohols; 3) Transformation of carboxylic acids into aldehydes.

ANSWER: 2 AND 3

TOSS-UP

23) Physics – *Short Answer* By what process can a quantum particle cross potential energy hills without expending any energy?

ANSWER: QUANTUM TUNNELING (ACCEPT: TUNNELING)

BONUS

23) Physics – *Short Answer* What is the potential energy, in joules to one significant figure, stored in the electric field of a capacitor if its capacitance is 10 to the negative 6 farads with a voltage of 100 volts?

ANSWER: 0.005 (DO NOT ACCEPT: 5 TIMES 10^{-3})